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Use of Accelerators U-150 and RIC-14 for Radionuclide Production

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From the point of the use for the radionuclide production of various nuclear reactions production accelerators can be divided into several groups depending on the proton energy.

Table 1Classification of cyclotrons for radionuclide production depending of proton energy

Proton Energy	**PET Cyclotrons ≤ 19 MeV**	**13-19 MeV**	**18-30 MeV**	**50-80 MeV**
Nuclear reaction	p, n	p, n; p, α	p, 2n; p, 2p; p, 3n	p, xn

Table 2. Manufacturers of the accelerators for radionuclide production

Manufacturer	**Accelerator model**	**Proton energy, MeV**	**Beam current μA**	**Quantity sheaves**
IBA RadioPharma Solutions	Cyclone® 18 Cyclone® 30 Cyclone® 70	18 30 70	150 400, 750 and 1500 750	2 2 2
Advanced Cyclotron Systems, Inc.	TR-19 TR-24 TR-30	19 24 30	□ 300 300; □ 1000 □ 1000	2 2 2
Best Cyclotron Systems, Inc. (BCSI)	Best 15 Best 25 Best 28 Best 35 Best 70	15 20, 25 28 35 70	400 400 400 1000 700	2 2 2 2 2
Scientific-Research Efremov Institute of Electrophysical Apparatus (NIIEFA)	CC-18 MGC-20 MCC-30/15	18 18/20 30	100 50/200 350	2 1 2
Sumitomo Heavy Industries, Ltd.("SHI")	HM-20 HM-30	20 30	- 1000	2 2

Criteria for a choice of the accelerator.

In our opinion to choose the accelerator it is necessary to use the following criteria:

1. Accelerator application - PET, radionuclide production, researches.

For the ultra-short-lived radionuclides production, as noted above, the proton energy should be less than 19 MeV. The intensity of the beam should not be very high, and it depends how the products will be used: for one or more PET scanners, only on-site or, for example, FDG will be also available in other clinics.

For the production of short-and long-lived radionuclides proton beams of high intensity are required.

2.What radionuclides are planned to produce.

3. What reactions are planned to be used for radionuclides production.

4. Possible design and starting materials of the target.

Paragraphs 2-4 determine the required energy of the protons, and paragraph 4 - the desired intensity of the beam.

Table 3. Main radionuclides produced by Cyclotron Co., Ltd.

Radionuclide	RIC-14	U-150	Separation method
Titanium-44	-	$^{45}Sc\ (p, 2n)\ ^{44}Ti$	Extraction + ion-exchange chromatography
Cobalt-56	$^{56}Fe\ (p, n)\ ^{56}Co$	-	Ion-exchange chromatography
Cobalt-57	-	$^{58}Ni\ (p, 2p)\ ^{57}Co$ $^{58}Ni\ (p; pn)\ ^{57}Ni \xrightarrow{\beta^+} {}^{57}Co$	Ion-exchange chromatography
Gallium-67	$^{67}Zn\ (p, n)\ ^{67}Ga$	$^{68}Zn\ (p, 2n)\ ^{67}Ga$	Extraction
Germanium-68	-	$^{69}Ga\ (p, 2n)\ ^{68}Ge$	Extraction
Strontium-85	*$^{85}Rb\ (p, n)\ ^{85}Sr$*	$^{85}Rb\ (p, n)\ ^{85}Sr$ $^{87}Rb\ (p, 3n)\ ^{85}Sr$	Ion-exchange chromatography
Yttrium-88	*$^{88}Sr\ (p, n)\ ^{88}Y$*	$^{88}Sr\ (p, n)\ ^{88}Y$	Extraction chromatography or co-precipitation
Palladium-103	$^{103}Rh\ (p, n)\ ^{103}Pd$	-	Extraction + ion-exchange chromatography
Cadmium-109	$^{109}Ag\ (p, n)\ ^{109}Cd$	-	Ion-exchange chromatography
Indium-111	$^{111}Cd\ (p, n)\ ^{111}In$	$^{112}Cd\ (p, 2n)\ ^{111}In$	Ion-exchange chromatography
Cerium-139	$^{139}La\ (p, n)\ ^{139}Ce$	-	Ion-exchange chromatography
Bismuth-207	*$^{207}Pb\ (p, n)\ ^{207}Bi$*	$^{207}Pb\ (p, n)\ ^{207}Bi$	Ion-exchange chromatography

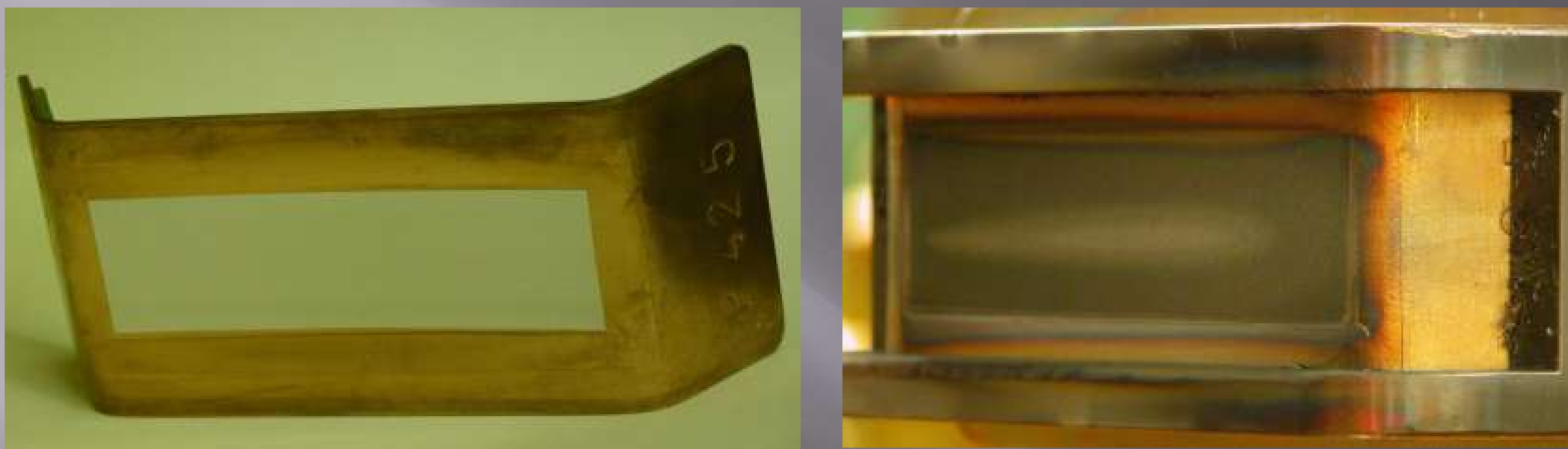
a)

a)

b)

Fig. 1 target for radionuclide cobalt-57

a)- before irradiation; b) - after irradiation



a) б)

Fig. 2 The target for radionuclide palladium-103

a) - before irradiation; b) - after irradiation

Conclusion

1. The cyclotrons available at our company allow to produce most of the currently used cyclotron radionuclides.

2.The production capacity can fully meet the needs of the domestic market and react quickly to changes in demand for domestic and foreign markets.

3. Considerable attention should be given to search new promising, from our point of view, radionuclides, and also to the development and organization of production of radionuclides, recently found application.

So three years ago, we developed a method for producing of germanium-71, which, in our opinion, can be used as an applicator for the treatment of skin diseases.

This year, the production technology of the radionuclide zirconium-89, which has recently become popular for use in PET, has been developed.

4. We still consider as important to improve the production technology the most popular of radionuclides in order to increase their productivity.